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MAN159–9604

T1500A SERVICE MANUAL

T1500A SERVICE MANUAL

WARRANTY

For a period of one year from its date of purchase new and undamaged from Polar Instruments Ltd, POLAR INSTRUMENTS LTD or its authorized distributors will, without charge, repair or replace at its option, this product if found to be defective in materials or workmanship, and if returned to POLAR INSTRUMENTS LTD or its authorized distributors transport prepaid. This warranty is expressly conditioned upon the product having been used only in normal usage and service in accordance with instructions of POLAR INSTRUMENTS LTD and not having been altered in any way or subject to misuse, negligence or damage, and not having been repaired or attempted to be repaired by any other than POLAR INSTRUMENTS LTD or its authorized distributors. EXCEPT FOR THE FOREGOING EXPRESS WARRANTY OF REPAIR OR REPLACEMENT POLAR INSTRUMENTS LTD MAKES NO WARRANTY OF ANY KIND, INCLUDING BUT NOT LIMITED TO, ANY EXPRESS OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE, AND POLAR INSTRUMENTS LTD SHALL NOT BE LIABLE FOR ANY DAMAGES, WHETHER DIRECT OR NOT OR OTHERWISE, BEYOND REPAIR OR REPLACING THIS PRODUCT.

DECLARATIONS

ELECTROMAGNETIC COMPATIBILITY

European Community Directive Conformance Statement

This product is in conformity with the protection requirements of EC Council Directive 89/336/EEC on the approximation of the laws of the Member States relating to electromagnetic compatibility.

A declaration of conformity with the requirements of the Directive has been signed by

POLAR INSTRUMENTS (UK) LTD
11 College Place
London Road
Southampton
England
SO1 2FE

This product satisfies EN50081-1:92 and EN 50082-1:92

SAFETY

WARNING The service instructions contained in this manual are for use by qualified electronic service personnel only.

WARNING

The LIVE and NEUTRAL lines on this unit are BOTH fused.

When the unit is connected to its supply, the opening of covers or removal of panels is likely to expose dangerous voltages.

GROUNDING

This unit must be earthed (grounded); do not operate the instrument with the safety earth disconnected. Ensure the instrument is connected to an outlet with an effective protective conductor terminal (earth). Do not negate this protective action by using an extension cord without a protective conductor.

Note: This instrument is fitted with 3-wire grounding type plug designed to fit only into a grounding type power outlet. If a special local plug must be fitted to the power cord ensure this operation is performed by a skilled electronics technician and that the protective ground connection is maintained. The plug that is cut off from the power cord must be safely disposed of.

Power cord color codes are as follows:

Europe

brown	live
blue	neutral
green/yellow	earth (ground)

United States

black	live
white	neutral
green	ground

POWER SUPPLY

Check that the indicated line voltage setting corresponds with the local mains power supply. See the rear panel for line voltage settings. Instruments with a serial number prefixed with a letter (e.g. A1234) are configured for 90 – 110 Volts only.

Changing the line voltage settings on this instrument must only be performed by a skilled electronics technician. Instructions for changing the line voltage settings are contained in Section 5.

OPERATION

> *This manual contains instructions and warnings which must be observed by the user to ensure safe operation. Operating this instrument in ways other than detailed in this manual may impair the protection provided by the instrument and may result in the instrument becoming unsafe. Retain these instructions for later use.*

The unit is designed for use indoors in an electrical workshop environment at a stable work station comprising a bench or similar work surface.

Use only the accessories (e.g. test probes and clips) provided by Polar Instruments.

The instrument must be maintained and repaired by a skilled electronics technician in accordance with the manufacturer's instructions.

If it is likely that the protection has been impaired the instrument must be made inoperative, secured against unintended operation and referred to qualified service personnel.

Protection may be impaired if, for example, the instrument:

- Shows signs of physical damage
- Fails to operate normally when the operating instructions are followed
- Has been stored for prolonged periods under unfavourable conditions
- Has been subjected to excessive transport stresses
- Has been exposed to rain or water or been subject to liquid spills

CAUTION

Electrical Isolation

Always disconnect the board under test from the local mains supply (including ground) before using this instrument.

Static Sensitive Devices

This unit contains Static Sensitive Devices. Static discharge can damage some electronic components. Care must be taken when handling these components. Observe appropriate precautions to avoid damage.

SPECIFICATIONS

ASA Test Ranges	Open Circuit Voltage	Short Circuit Current
Junction	1V	500µA
Logic	10V	5mA
Low	10V	150mA
Med	20V	1mA
High	40V	1mA
Hi-Cap (1Hz fixed)	10V	150mA
Low-Cap (2kHz fixed)	10V	20µA
ASA Test Frequencies		
Low	95Hz	
Medium	500Hz	
High	2kHz	
Display	Internal CRT	

ENVIRONMENTAL OPERATING CONDITIONS

The instrument is designed for indoor use only under the following environmental conditions:

Altitude	Up to 2000m
Temperature	+5°C to +40°C ambient
Relative humidity	RH 80% maximum at 31°C — derate linearly to 50% at 40°C
Mains borne transients	As defined by Installation Category II (Overvoltage Category II) in IEC664
Pollution Degree	2 (IEC664)

Power Requirements

230V ± 10%, 115V ± 10% or 100V ± 10% at 50/60Hz, 40VA.

Fuses

230V 160mA T
115V 315mA T

Channel A and B Output Fuses

160mA Fast

Physical characteristics (excluding accessories)

Dimensions	300 mm (11.8 in.) wide 110 mm (4.4 in.) high 260 mm (10.3 in.) deep
Weight	1.5 kg (3.3 lb.)

SYMBOLS

⚠ REFER TO MANUAL	These sockets are for connecting only Polar Instruments probes and connectors for use as described in the Operator Manual. To prevent damage to this product and to ensure its safe use observe the specifications given in this manual when connecting to terminals marked with this symbol.
⏚ COM	This terminal is internally connected to earth (ground).

ACCESSORIES

Standard Accessories

Probe set	MMP159
Test clip set	ACC110 (Red) ACC111 (Black)
Operator manual	MAN151

CONTENTS

SECTION 1 – PERFORMANCE CHECK

MAINTENANCE AND CALIBRATION OF INSTRUMENTS

For most of Polar Instruments' products there are two maintenance procedures — the **Performance Check** and the **Adjustment Procedure.** Some instruments may have a single (combined) procedure.

Performance Check

The Performance Check (or Checkout Procedure) is used to verify the basic functions of the instrument. This does not usually require the removal of instrument covers, but may require the use of external test equipment. This procedure is not intended to verify the calibration of the instrument.

Adjustment Procedure

The Adjustment Procedure (or Calibration Procedure) is used to check and, if necessary, adjust the instrument's calibration settings. Before carrying out the Adjustment Procedure the instrument's Performance Check (if applicable) should be carried out, and any detected defects should be rectified. *The Adjustment Procedure and rectification of defects should only be carried out by qualified technician.*

Recommendations for Routine Maintenance

Where a Performance Check is available for an instrument this may be used as required to confirm the basic operation of the product.

To maintain the calibration of an instrument it is recommended that its Calibration/Adjustment Procedure is carried out at intervals not exceeding 12 months.

PERFORMANCE CHECK

Procedure

1. Connect the T1500A to a suitable source of power, turn on and allow to warm up for 20 minutes.
2. Short A to COM and adjust the position controls to confirm their operation. Set the trace for a “+” display. Check that the ends of the traces can be seen — adjust trace intensity if needed. Check the display is focused.
3. Check each range and frequency combination and confirm the display maintains a cross. Some looping may be seen in LOCAP range.
4. Short B to COM instead of A. Check the display again for a cross — check the “cross” display is maintained in all ranges.
5. If desired a further check on the ranges may be made by testing components as follows:

RANGE	TEST COMPONENT	DISPLAY
HIGH	47KΩ	Diagonal Line
MED	22KΩ	Diagonal Line
LOW	56Ω	Diagonal Line
LOGIC	2K2	Diagonal Line
JUNC	2K2	Diagonal Line
LOCAP	200pF	Circle
HICAP	2,200µF	Circle

Note: the quality of the component may affect the display seen — this table uses commonly available parts to check that no major faults exist in the product.

SECTION 2 – CALIBRATION

CALIBRATION PROCEDURE

> *WARNING: Hazardous voltages are exposed on the PCB when the cover is removed with power applied and for up to five minutes after power is removed. This procedure should only be performed by a technically qualified person aware of the hazards and taking all reasonable care.*

Equipment required

DVM
Insulated trimmer tool for adjusting preset potentiometers

Calibration procedure

1. Warm up the instrument for 20 minutes in LOGIC range and MED frequency then remove the cover.
2. Measure the line voltage. If available use a variable transformer to set it to the nominal line setting, e.g. 230V (or 115V).
3. Measure the voltage at R41 (4K7) and adjust R4 if necessary for 220V at nominal line voltage.

   If the line voltage is not at nominal value calculate the setting as follows:

   Voltage at R41 = 220V + (percent error from nominal line voltage x 20)

   e.g., if the line voltage is 240V, this is 4.3% high,

   ∴Voltage at R41 = 307V

   This optimises the range of the high voltage regulator.
4. Short A to COM
5. Adjust the intensity control to minimum. Adjust R241 (middle pot of the three) on the CRT board for a very dim trace. Set the intensity to normal viewing level.
6. Adjust R105 and R126 on the CRT board for a sharp, well focused trace.

7. Adjust R27 to set the trace length of the horizontal trace so that both ends are just visible.
8. Adjust R32 to align the trace with the horizontal graticule line.
9. Adjust the front panel Trace Rotation control to rotate the trace if necessary to align with the horizontal graticule line.
10. Remove the short from A to COM and short B to COM.
11. Adjust R17 to set the trace length of the vertical trace so that both ends are just visible.
12. Adjust R33 to align the vertical trace with the vertical graticule line — adjust R19 to rotate it if necessary.
13. Refit the cover and retaining screws.

SECTION 3 – CIRCUIT DESCRIPTION

T1500A CIRCUIT DESCRIPTION

Sine generator

Refer to the T1500A Sine Generator schematic
Oscillator U10B runs at 2MHz and is controlled by crystal X1. This forms the master clock which sets the frequency of all outputs and system timing. Binary counter U11 reduces the clock to the four source frequencies for the sine wave generator, 1MHz, 250kHz, 62.5kHz, and 488Hz.

Dual data selector U18 selects one of these frequencies and by its second “pole” selects the display alternating clock. C9 supplies one cycle A then one cycle B while C10 supplies two cycles A then two cycles B.

Synchronous counters U12 and U16 together form the address counter for Read Only Memory (ROM) U13 which holds the sine wave in digital form. Waveform data bytes are progressively clocked out to Digital to Analog Converter (DAC) U14 which produces a differential current output at pins 2 and 4.

The magnitude of the current is set by R114, pin 14 being a virtual earth. U15B converts the current to a voltage sine wave of 5V pk at pin 7. R201 and C66 form a filter to remove transients from the converter at MEDIUM and HIGH frequencies and C67 is added for LOW frequency by analogue switch U17A.

U15C converts the $5V_{pk}$ to $8V_{pk}$ to drive the output stages, while U15A reduces the signal to 2.5V pk for internal use but also applies phase correction by C41 and C40 when switched in by JUNCTION range.

Sine drivers

Refer to the T1500A Sine Drivers schematic
Power op-amps U8 and U9 provide the drive for outputs B and A respectively for all but MEDIUM, LOCAP and HIGH ranges. The op-amps’ gain is set by R_f of 20K and R_i of 16K to amplify the $8V_{pk}$ reference to $10V_{pk}$. Protection is provided by the 160mA fast-blow fuses and the 11V Zeners which hold the output of the op-amp at a safe level until the fuse opens. The 1R0 and 0.1uF snubber stabilises the feedback circuit.

The high voltage drivers are also op-amps, built with discreet transistors, with R_i of 24K and R_f of 162K amplifying the reference to just over 50V pk. The 3.3µF capacitor shifts the DC level of the sine wave from about 60V to symmetrical about ground at the output. D50 and D53 (D57, D54) balance the charge in the capacitor C35 (C36). Protection is provided by varistor R98 (R99).

Switching

Refer to the T1500A Switching schematic
Each range comprises a different combination of output voltage and source (series) resistance. In addition, with the exception of the specialised ranges, a choice of three frequencies can be made. LEDs confirm the button selection made and are interlocked so that the specialised ranges which force the frequency also turn off the FREQUENCY LEDs.

The voltages at the outputs are sensed by the Input Amplifiers (refer to T1500A Amplifier schematic) whose R_i resistors are selected by the switches. Note that there are two R_i resistors of 100K (R80, R81) and of 1M0 (R78, R79) and that the pair not used are grounded so that they cannot affect the op-amps' virtual earth inputs at "A INP" and "B INP".

In the remainder of this section we describe each range (Channel A components only). R_i for the Input Amplifier (refer to T1500A Amplifier schematic) is R78 unless stated otherwise.

For HIGH range the source resistor is a combination of R72, and the dividers R204, R74 and R76.

The MEDIUM range selects the divider R76, R74, R204 to obtain $20V_{pk}$ at a source resistance which is a combination of the divider and R71.

The LOW range uses the 10V source with resistors R54 and R55.

The LOGIC range uses the 10V source with R57.

The JUNCTION range obtains its 1V from divider R65, R60 which also provides the source resistance. Note: this range uses R80, 100K, as R_i for the Input Amplifier.

The LOCAP range is a specialised range for low value capacitors and uses a unique combination of resistance and frequency. Frequency is forced to the HIGH range by pulling FREQA and FREQB lines low. Source resistance is R61 and R68 and voltage is 20V from the divider, however as the amplifier input is 1M0 the actual output is half this at 10V.

The HICAP range is dedicated to large value electrolytic capacitors and uses the LOW range resistors and voltage source but forces a very low frequency not available in any other mode. This is performed by opening CKSEL from ground when S6 is pressed allowing both FREQA and FREQB to go high.

Amplifier

Refer to the T1500A Amplifier schematic
The Input Amplifiers are comprised of U20C and U20D whose gain is controlled by feedback resistors (R_f) selected by analog multiplexer U21. The gain is set so that the peak voltage on any range will be 2.5V at XA or XB. Note that the input resistors (R_i) for the op-amps are shown on the Switching schematic.

The outputs of these amplifiers drive the CRT X (horizontal) plates and are also combined with the 2.5V reference sine wave, via op-amps U20A and U20B, to generate the Y (vertical) signal. Phase correction is provided by C60 (C62) and is increased in LOCAP range by the 330pF of C61 switched in by analog switch U17.

Analog switch U19 provides the alternating display of Channel A and Channel B on the CRT by switching between them at the ALT_CLK rate. XDRIVE and YDRIVE are the virtual earth inputs to the CRT drive op-amps (refer to the T1000A Power Supplies schematic). R142 to R145 are the input resistors for the CRT drive op-amps; position offset for channel A is supplied via R122 – R125. When Channel B is selected, to prevent switching aberrations the Channel A source is held close to ground by diodes D81, D82 for X and the “Z” switch element for Y.

CRT

Refer to the T1500A CRT schematic
The high voltage supply connects to the anode of D14, whose cathode in turn connects to the CRT cathode. The CRT cathode is therefore 91V less negative than the high voltage supply and this allows the grid to be biased from a potential divider between cathode and supply. The divider consists of R108, R109 and potentiometer R241. R240 connects to the CRT grid, the transistor of opto-coupler ISO1 is placed in parallel with R108. By increasing the conduction of this transistor the grid can be driven more negative and the CRT trace is dimmed. The range of this variation is set by R241 to match the CRT characteristics.

Other bias voltages are obtained by dividers for control of focus and astigmatism. A fast blanking path to the grid is provided by C55 but protection is provided by D69 for start up and switch off transients.

Power supplies

Refer to the T1500A Power Supplies schematic

High voltage supply

All supply voltages are obtained from the mains transformer. Diode capacitor arrangements supply the regulators for the low voltage and +180V supply but the high voltage is generated by a multiplier from the 150 volt winding producing about –1500V, depending on line voltage.

When the high voltage regulator is operating, the supply to the CRT is at about –1400V so the +ve side of the –1500V multiplier output is at +100V and the return to earth is through Q6. Op-amp U4 compares the –1400V to +15V and adjusts the conduction of Q6 to maintain this. For example, if the supply dropped from –1400V to –1450V then the op-amp input would go –ve and its output –ve, turning off Q6. The volt drop across Q6 would rise and the multiplier output would lift the high voltage output back to –1400V.

Diode D4 and varistor R3 limit the voltage at Q6 collector to within safe limits during start-up or fault conditions. C27 increases loop gain at 50Hz to reduce ripple on the supply.

Low voltage supplies

Low voltage supplies are simple series pass regulated, but note that the CMOS switches are fed from a current limited supply VEE and VDD

The +180V supply also uses a series pass regulator but R1 is needed to limit the maximum volt drop at switch on or fault condition.

X and Y-plate drivers

The X-plate driver consists of gain setting op-amp U5B into whose virtual earth is added an offset to centre the display on the CRT screen. U5A inverts the output of U5B to generate a true push-pull signal for the CRT plate driving transistors.

The Y-plate driver is similar. To obtain trace alignment in the vertical axis a little Y signal is fed into the X amp and similarly to align the horizontal a little X signal is fed to Y. The pots are connected across the push pull so each signal is available in phase at one end of the pot to zero at centre and out of phase at the other end.

R51 and R30 set the current into the LED of opto-coupler ISO1 (refer to T1500A CRT schematic) to set the intensity while U7A and B produce pulses at the edges of the Alternate clock to create blanking pulses to the CRT.

SECTION 4 – DISMANTLING INSTRUCTIONS

DISMANTLING THE T1500A

- *Ensure the power cord is removed and the unit has been turned off for at least five minutes*.
- Remove the CRT base and then the four screws holding the shield to the front panel. Remove the CRT and graticule and gasket.
- Remove the two screws retaining the power inlet and lift it off its lugs.
- Remove the three wires from the probe sockets.
- Remove the two screws and lift the intensity pot board away from the front moulding.
- Remove the screws retaining the panel and main boards to the case.
- Pull off the power button and hold the switch in while lifting the rear of the board to release it from the case. Lift the boards out of the case.

SECTION 5 – LINE VOLTAGE AND FUSE CHANGING

WARNING: There are hazardous voltages inside the instrument when connected to its power supply. REMOVE THE POWER CORD before touching any part of the line input circuit. Note that high voltages may continue to be present for 5 minutes after power is removed until internal capacitors discharge.

LINE VOLTAGE SELECTION AND FUSE CHANGING

Note: *When replacing fuses always use the type and rating stated in SPECIFICATIONS.*

Changing the line voltage

- *To change the line voltage disconnect the power cord and wait five minutes for internal voltages to discharge if the unit has just been running*.
- Remove the two screws which retain the cover and lift the rear of the cover then remove it completely.
- Remove the line select link(s) with pliers from their sockets adjacent to the power transformer. Replace one link for 240V or two for 120V in the marked locations. The links are made of 1mm diameter wire if replacements are needed.
- Remove the two line fuses F1 and F4 and replace with the correct values listed in “SPECIFICATIONS”.
- Obliterate the marking on the rear label and clearly mark the new setting.
- Refit cover and retaining screws.
- Connect to a suitable supply and confirm operation.

Fuse Replacement.

- The line fuses are located near the power inlet connector*. Replace only with parts of the value listed in “SPECIFICATIONS”. Note that Neutral and Live are both fused*.
- The Output Fuses for LOW, LOGIC, JUNCTION, and HICAP ranges are located alongside the CRT. One fuse is supplied for A channel and one for Channel B.

  See “SPECIFICATIONS” for the value of fuses.
- Note: See Section 8 – REPLACEMENT PARTS for information on the fuse wired into the CRT heater circuit.

SECTION 6 – FAULT DIAGNOSIS

WARNING: Hazardous voltages are exposed on the PCB when the cover is removed. These procedures should only be performed by a technically qualified person aware of the hazards and taking all reasonable care.

TROUBLESHOOTING HINTS

- Check all power supply voltages.
- Using an oscilloscope with 10X probe check that a sine wave drive appears at the probes. If not, check the Sine Generator at U15 pin 7. If no sine waves appear here check the crystal oscillator and clock switching to the address counter U12.
- If a fault is restricted to one or two ranges then this may point to the circuit which is at fault; for instance, a vertical line in LOW, LOGIC, and JUNCTION on Channel B only indicates a failure of the Channel B low voltage drive circuit (probably the output fuse).
- If a sine wave can be measured at the probes but the display is wrong then it is the input amplifier or plate driver circuits which are at fault.
- With probes open circuit a sine wave should be observed at U20 pins 8 and 14 (2.5V pk).
- With probes shorted to COM a sine wave (2.5V pk) should be measured at U20 pins 1 and 7.
- No useful measurements may be made around U19 as this switch is in the virtual earth of the plate driver op-amps.

SECTION 7 – MAINTENANCE AND CLEANING

Cleaning

Clean the unit with a cloth lightly moistened with water with a small amount of mild detergent.

Alternatively, a cloth lightly moistened with alcohol (ethanol or methylated spirit) or isopropyl alcohol (IPA) may be used.

Do not spray cleaners directly onto the instrument.

Technical Support

For technical support contact your local Polar Instruments distributor or Polar Instruments Ltd. at the address at the front of this manual.

Instrument repair

If it becomes necessary to repair the instrument, in the first instance contact the Polar Instruments distributor in your country. In case of difficulty contact Polar Instruments Ltd. at the address at the front of this manual. *Do not send the instrument until shipping instructions have been received from the repairer.*

SECTION 8 – REPLACEMENT PARTS

To ensure correct parts are supplied, orders for replacements should include the following details:

Instrument type
Instrument serial number
Firmware version (if applicable)
Circuit reference (if applicable) and description
Note: Parts marked with an asterisk (*) have been subject to modification in later instruments.

Safety critical parts (listed in bold type) must be replaced with parts obtained from Polar Instruments Ltd. or your Polar Instruments distributor to ensure continued safe operation.

CRT BOARD PARTS

PART Nº	Quantity	Description	Circuit Reference
CVD139	1	470pF 2KV CERAMIC	C55
DZA306	2	91V ZENER DIODE	D14, D69
ICA247	1	OPTO-ISOLATOR	ISO1
MPC177	1	PCB to D692-6	
MQX181	**1**	**CRT BASE**	
RCC110	1	1000V 4M7	R104
RCF000	1	LINK	
RCF100K	1	RESISTOR 100K 1/4W 5%	R107
RCF1M0	3	RESISTOR 1M0 1/4W 5%	R108, R109, R240
RCF470K	1	RESISTOR 470K 1/4W 5%	R106
RVB324	3	1M0 PRESET	R105, R126, R241
WMA182	1	.1" PITCH RIBBON 8-WAY	JP4

MAIN BOARD/PANEL PARTS

PART Nº	Quantity	Description	Circuit Reference
CEA103	5	10µF Electrolytic	C2, C6, C7, C9, C29
CEA104	1	1000µF Electrolytic	C30
CEA105	2	220µF Electrolytic	C31, C32
CEA107	8	4.7µF 450V Electrolytic	C19, C20, C21, C22, C23, C24, C25, C26
CEA108	1	22µF 350V Electrolytic	C1
CEA117	2	2,200µF 25V	C16, C17
CEA118	2	3.3µF 250V Electrolytic	C35, C36
CVD101	3	0.1µF Polyester	C10, C33, C34
CVD102	2	0.01µF Polyester	C37, C67
CVD106	2	82pF Ceramic	C60, C62
CVD140	26	0.1µF Ceramic Axial	C3, C4, C5, C8, C13, C14, C15, C28, C44, C45
CVD115	5	33pF Ceramic	C38, C46, C47, C48, C49,
CVD116	1	100pF Ceramic	C39
CVD119	2	270pF Ceramic	C12, C18
CVD121	3	330pF Ceramic	C41, C61, C63
CVD123	2	15pF Ceramic	C64, C65
CVD142	1	.01µF 1500V Poly	C27
CVD143	1	0.1µF Polyester Box	C11
CVD146	2	1nF Polyester	C40, C66
CVD147	1	4n7F Polyester	C42
CVD154	1	2n2F Polyester	C43
CVD155	1	470pF Polypropylene	C67
CVD156	2	DIP Decouplers	U12, U16

PART Nº	Quantity	Description	Circuit Reference
DSP101	9	1N4148	D2, D3, D7, D8, D9, D40, D41, D42, D43
DSP102	30	1N4007	D1, D4, D5, D6, D10, D11, D12, D13, D14, D15, D16, D17, D20, D21, D22, D23, D24, D25, D26, D27, D28, D29, D30, D31, D51, D52, D53, D54, D55, D56
DSP104	2	BAT42	D81, D82
DZA316	2	62V Zener Diode	D50, D57
DZA321	4	12V Zener Diode	D46, D47, D48, D49
DZA323	2	5V1 Zener Diode	D18, D19
FCA114	2	160mA F	F2, F3
FCA121	2	160mA T	F1, F4
FCA122	X	315mA T	110V
FCA130	1	0.5A T Wire Ended	F5
FSW135	1	ROM	U13
ICA120	1	LF351	U4
ICA128	1	7805	U1
ICA169	1	74HC161	U16
ICA173	1	74HC04	U7
ICA186	3	TL084	U5, U15, U20
ICA210	1	4040B	U11
ICA240	1	4053B	U19
ICA241	1	4052B	U21
ICA244	1	74HC153	U18
ICA245	1	DAC0800	U14
ICA246	2	LM759	U8, U9
ICA248	1	7815	U2
ICA249	1	7915	U3
ICA250	1	TL783	U6
ICA291	1	74HC590	U12
ICA297	1	4066	U17
ICA305	1	T4C04/4069B	U10
LDD124	1	2Mhz Crystal	X1
LED115	10	Red LEDs	D32, D33, D34, D35, D36, D37, D38, D39, D44, D45
MAA123	2	Fuse Holder	F1, F4
MAA123A	2	Fuse Holder	F2, F3
MMP167	2	Heatsink Wide	
MMP169	1	Heatsink narrow	
MNS111	4	M3 x 6 Pan Head	
MNS112	3	M3 Nut	

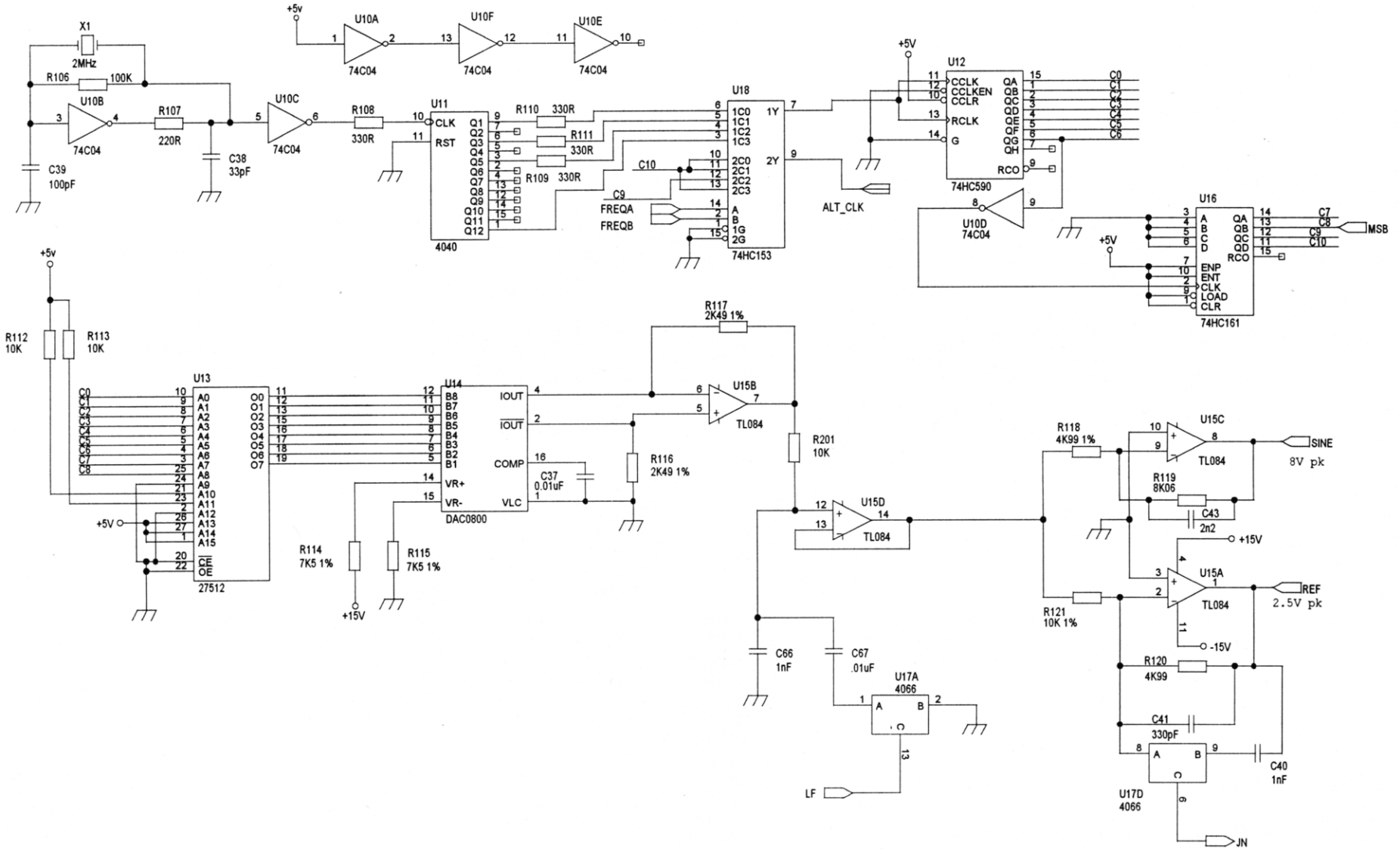
PART Nº	Quantity	Description	Circuit Reference
MNS117	3	M3 x 10 Pan Head Screw	
MNS125	3	M3 Lockwasher	
MNS174	4	M3 Washer	
MPCD1028	1	Main PCB	
MPCD1029	1	Panel PCB	
MPCD1030	1	Pots PCB	
MPP143	2	Heatsink Insulators	
MPP158	2	Spindle	
MPP200	10	LED Spacers	
MQX299	1 (2)	Line Select Link	240V (110V)
MQX300	4	Line Select Sockets	
MSH104	1	M3 Solder Tag	
QNN303	12	MPSA42	Q1, Q2, Q3, Q4, Q7, Q8, Q9, Q10, Q11, Q12, Q13, Q14
QNN304	1	2N3904	Q5
QNN306	1	BUX87	Q6
RCC110	3	4M7 (750V)	R45, R46, R47
RCC129	2	82ZA2 Varistor	R98, R99
RCC130	2	15K 2.5W	R94, R105
RCC131	1	V120ZA1	R1
RCC132	1	V250LA4	R2
RCC133	1	V22ZA1	R6
RCC134	1	V56ZA2	R7
RCC147	1	Z15L471	R3
RCC137	4	47K 1W	R20, R21, R22, R23
RCC138	4	Resistor 33R 1W 5%	R52, R53, R54, R55
RCF000	2	Link	LK1, LK2
RCF100K	4	Resistor 1/4W 5%	R34, R106, R122, R123
RCF10K	10	Resistor 1/4W 5%	R16, R28, R35, R63, R64, R112, R113, R134, R135, R201
RCF10R	4	Resistor 1/4W 5%	at U19, U21
RCF12K	2	Resistor 1/4W 5%	R68, R69
RCF150K	1	Resistor 1/4W 5%	R5
RCF1K0	5	Resistor 1/4W 5%	R29, R36, R42, R84, R87
RCF1M0	4	Resistor 1/4W 5%	R31, R43, R44, R48
RCF1R0	4	Resistor 1/4W 5%	R82, R83, R85, R86
RCF220R	1	Resistor 1/4W 5%	R107
RCF2K7	2	Resistor 1/4W 5%	R12, R49
RCF330R	6	Resistor 1/4W 5%	R66, R67, R108, R109, R110 R111
RCF33K	1	Resistor 1/4W 5%	R30
RCF470K	2	Resistor 1/4W 5%	R18, R24

PART Nº	Quantity	Description	Circuit Reference
RCF470R	2	Resistor 1/4W 5%	R202, R203
RCF47K	2	Resistor 1/4W 5%	R97, R100
RCF4K7	3	Resistor 1/4W 5%	R8, R11, R41
RCF7K5	4	Resistor 1/4W 5%	R9, R10, R25, R26
RCF820R	4	Resistor 1/4W 5%	R92, R93, R103, R104
RCT100K	2	Resistor 1/4W 1%	R80, R81
RCT10K	1	Resistor 1/4W 1%	R121
RCT124K	2	Resistor 1/4W 1%	R136, R141
RCT12K	2	Resistor 1/4W 1%	R204, R205
RCT162K	2	Resistor 1/4W 1%	R96, R102
RCT16K	2	Resistor 1/4W 1%	R90, R91
RCT1K0	1	Resistor 1/4W 1%	R13
RCT1M0	4	Resistor 1/4W 1%	R61, R62, R78, R79
RCT20K	8	Resistor 1/4W 1%	R58, R65, R73, R74, R75, R76, R88, R89
RCT249K	2	Resistor 1/4W 1%	R137, R139
RCT24K	2	Resistor 1/4W 1%	R95, R101
RCT2K0	2	Resistor 1/4W 1%	R56, R57
RCT2K2	2	Resistor 1/4W 1%	R59, R60
RCT2K49	2	Resistor 1/4W 1%	R116, R117
RCT43K	2	Resistor 1/4W 1%	R72, R77
RCT47K	16	Resistor 1/4W 1%	R37, R38, R39, R40, R126, R127, R128, R129, R130, R131, R132, R133, R142, R143, R144, R145
RCT62K	2	Resistor 1/4W 1%	R138, R140
RCT4K99	2	Resistor 1/4W 1%	R118, R120
RCT68K	2	Resistor 1/4W 1%	R14, R15
RCT7K5	2	Resistor 1/4W 1%	R114, R115
RCT8K06	3	Resistor 1/4W 1%	R70, R71, R119
RVB313	4	Preset Pot 47K	R17, R27, R32, R33
RVB314	2	Preset Pot 47K	R50, R51
RVB325	1	Preset Pot 1M0	R19
RVB326	1	Preset Pot 22K	R4
RVP114	2	Panel Pot 100K	R124, R125
SWB133	**1**	**Power Switch**	**S1**
SWB158	1	Switch Assembly	S2 to S11
TXM128	**1**	**Transformer**	**T1**
WMA186	0.3m	Silicone Wire	
WMA244	0.18m	6mm PVC Sleeving	
WMA294	1	5 Way link cable	
WMA295	1	13 Way link cable	
WMA296	1	4 Way link cable	

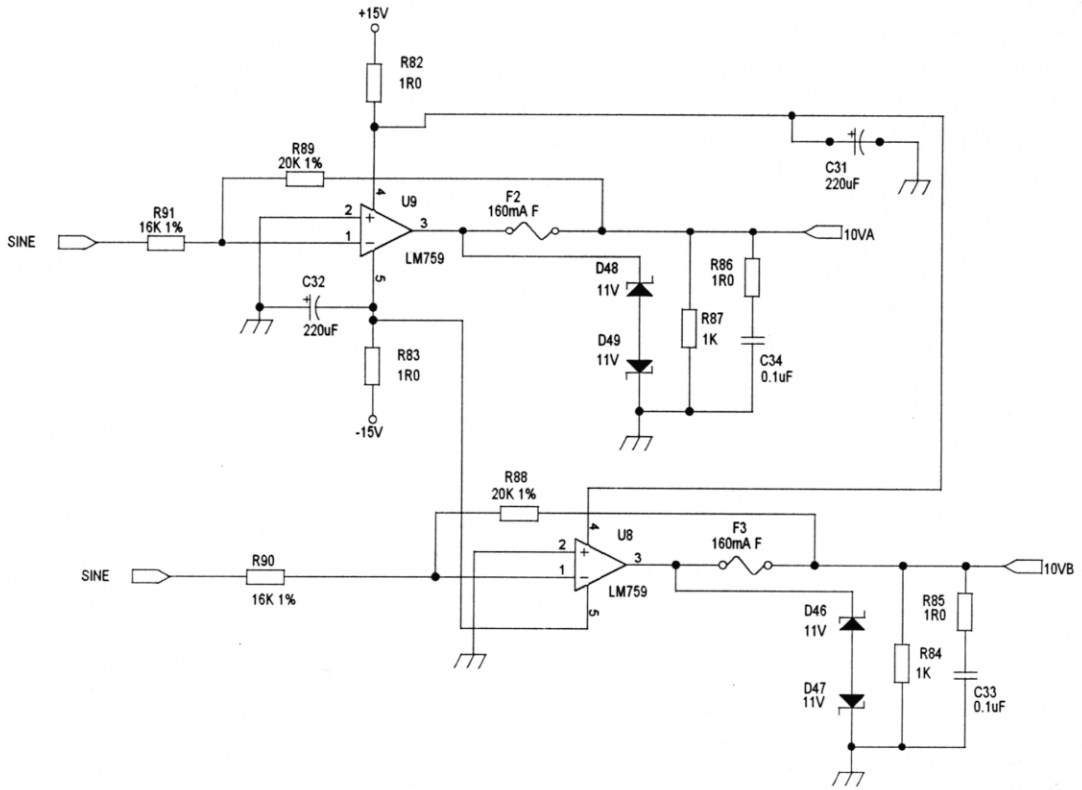
MECHANICAL PARTS

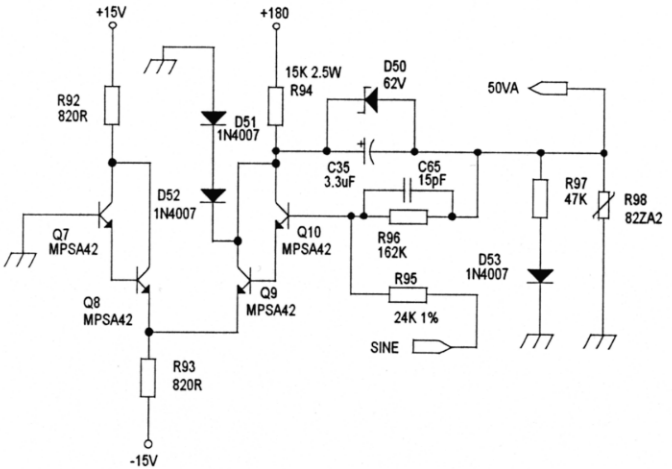
PART Nº	Quantity	Description
LDD102	1	CRT
MCA138	1	Case Top
MCA139	1	Case Bottom
MCA162	1	Front Moulding
MKB127	2	Knob Cap
MKB128	2	Knob
MKB129	10	Button caps
MKB153	1	Power Switch Button
MMP121	2	Safety Label
MMP166	1	CRT Shield
MNS107	12	K30 x 6 Self Tap
MNS117	2	M3 x 10 Pzd Screw
MNS125	4	M3 Lockwasher
MNS160	4	M3 x 12 Pzd Screw
MNS163	2	M3 x 12 Csk Head Screw
MNS166	4	Starlock
MNS175	2	M3 Flangenut
MNS176	6	K30 x 8 Self Tap
MPA137	0.035m	32mm Heatshrink (Adhesive)
MPA165	0.15m	4.8mm Heatshrink
MPP191	2	Tilt Leg
MPP193	4	Stick_on Feet
MPP198	2	Tilt Base
MPP230	1	Tie Wrap
MPP231	2	Insert Cover
MPP209	1	CRT gasket, soft
MQX179	2	Red 4mm Socket
MQX180	1	Black 4 mm Socket
MQX254	**1**	**IEC Inlet**
MWP156	1	S/No Label
MWPD1031	1	Front Label
MWP1058	1	REAR LABEL
WMA102	0.075	Blue Wire
WMA103	0.075	Brown Wire
WMA104	0.075	Green /Yellow wire

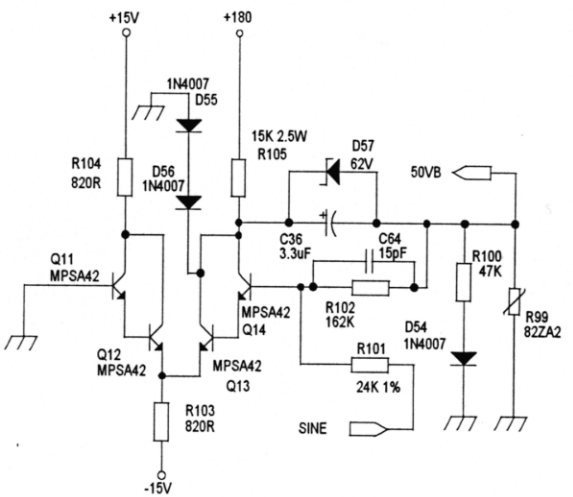
SECTION 9 – SCHEMATIC DIAGRAMS



Polar	Polar Instruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. T1500A	Title Sine Generator

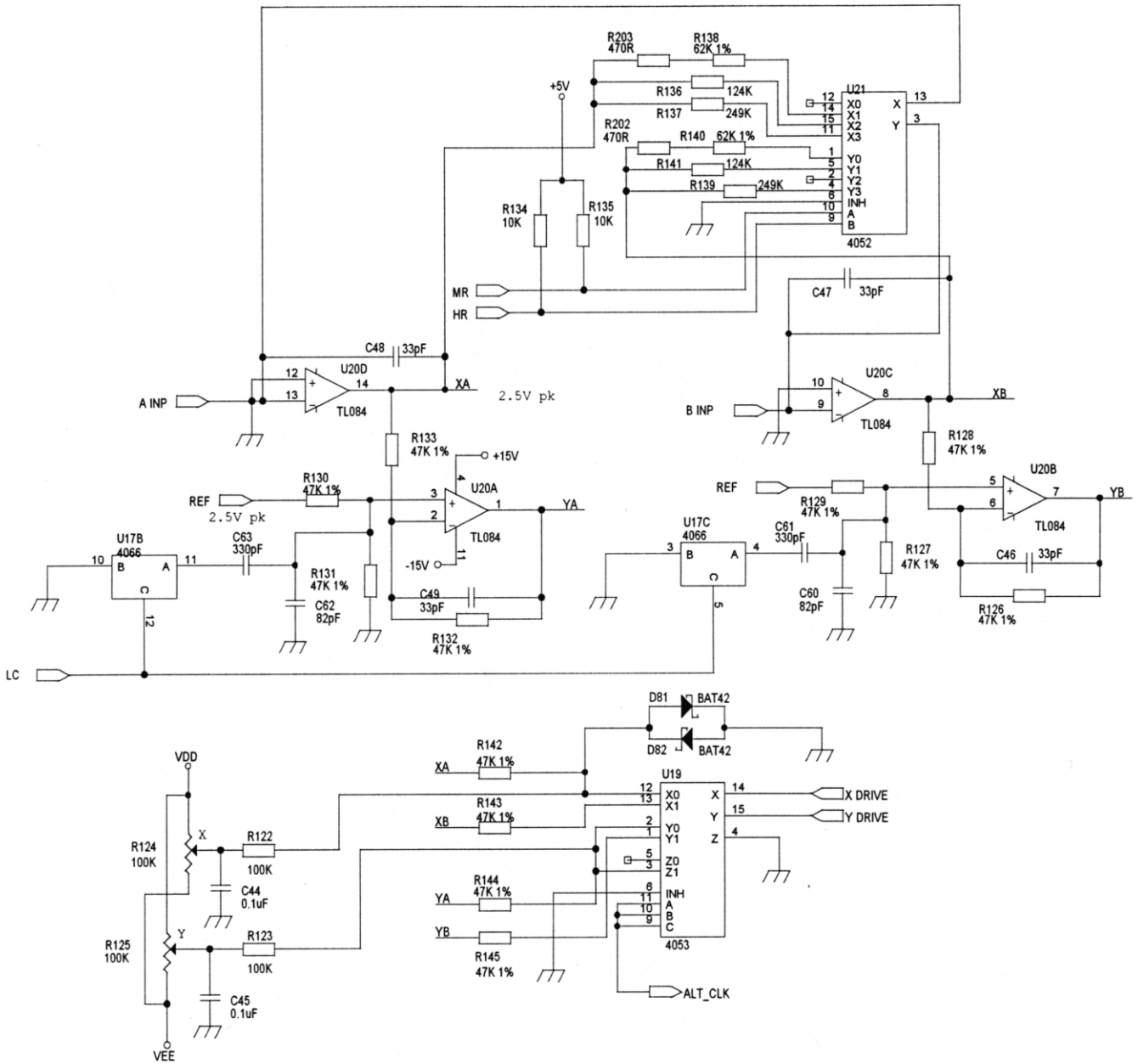




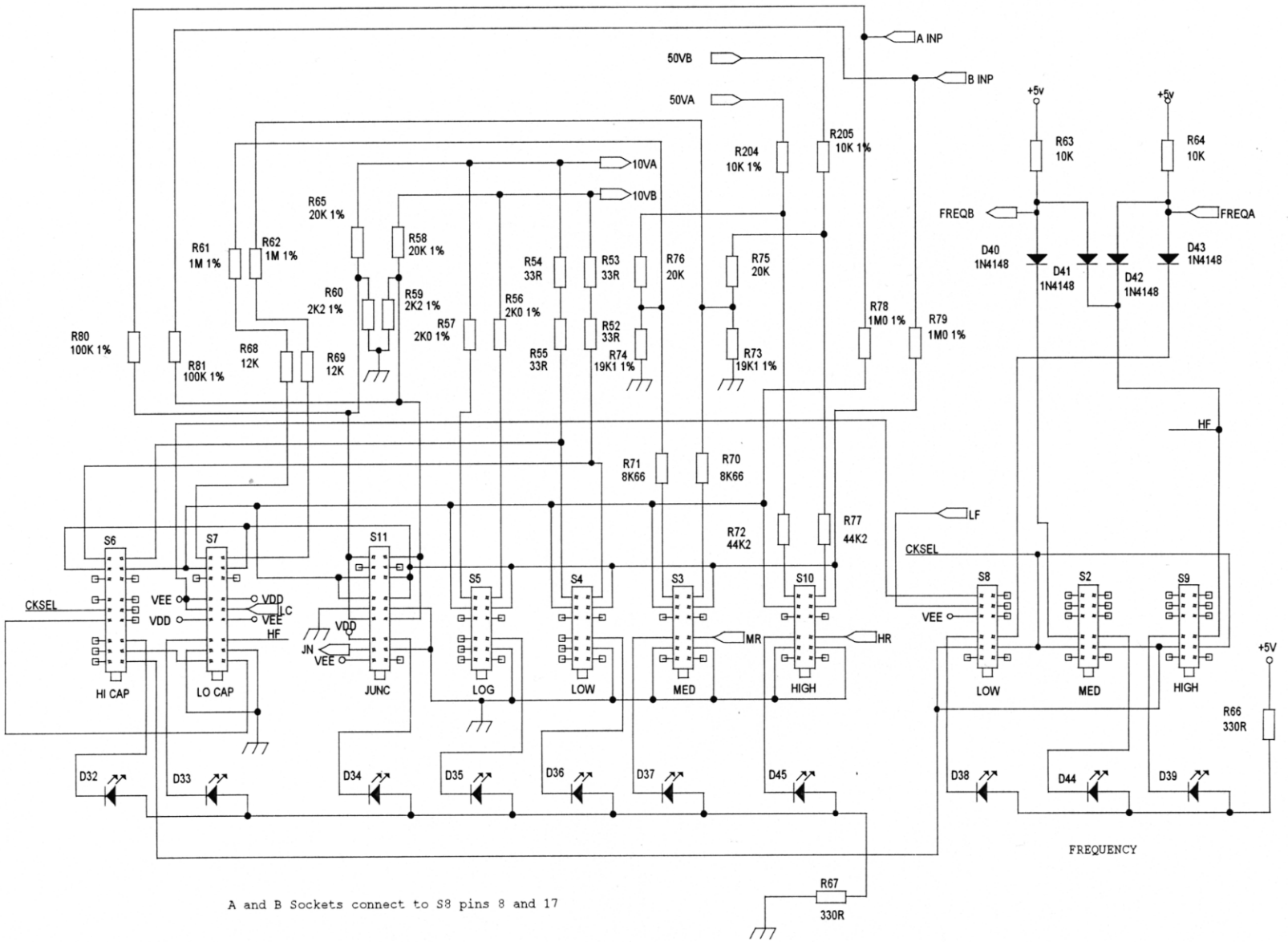


Polar Instruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands

Inst.	Title
T1500A	Sine Drivers



Polar Instruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands	
Inst. T1500A	Title Amplifier

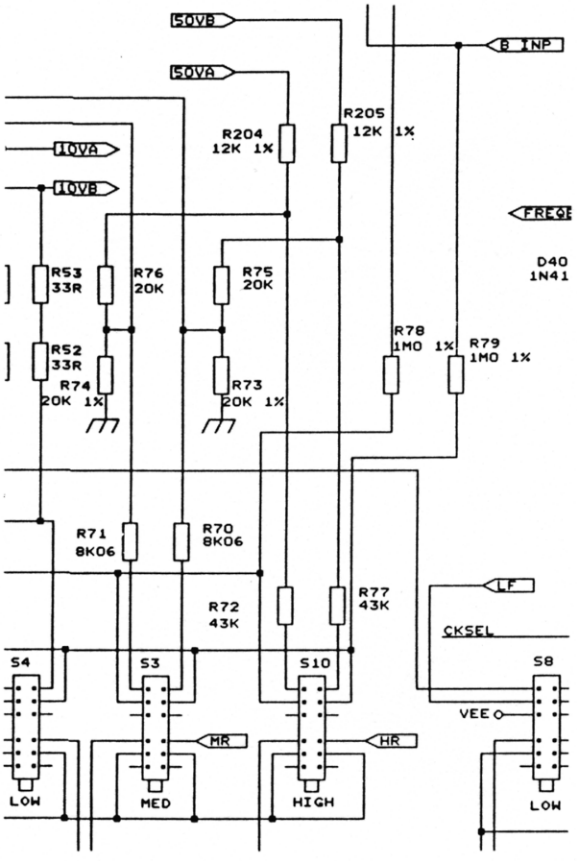


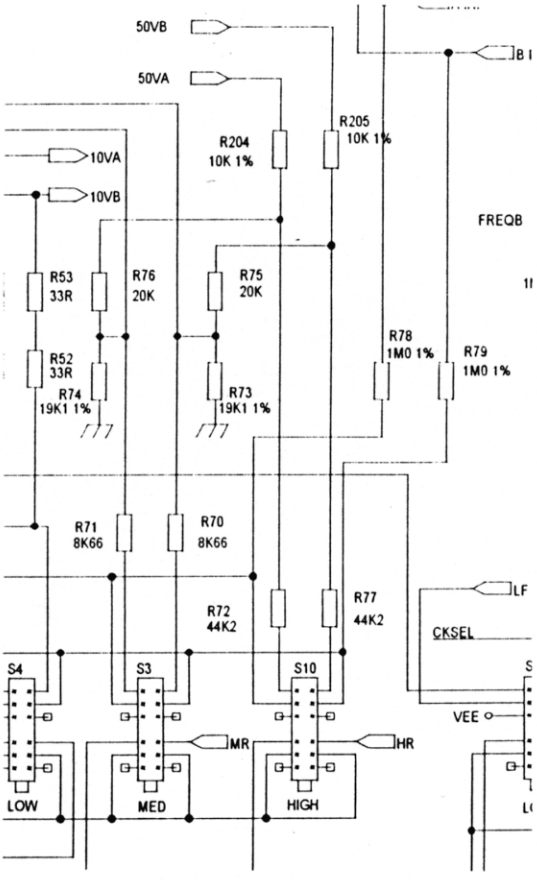
Polar Instruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands	
Inst. T1500A	Title Switching

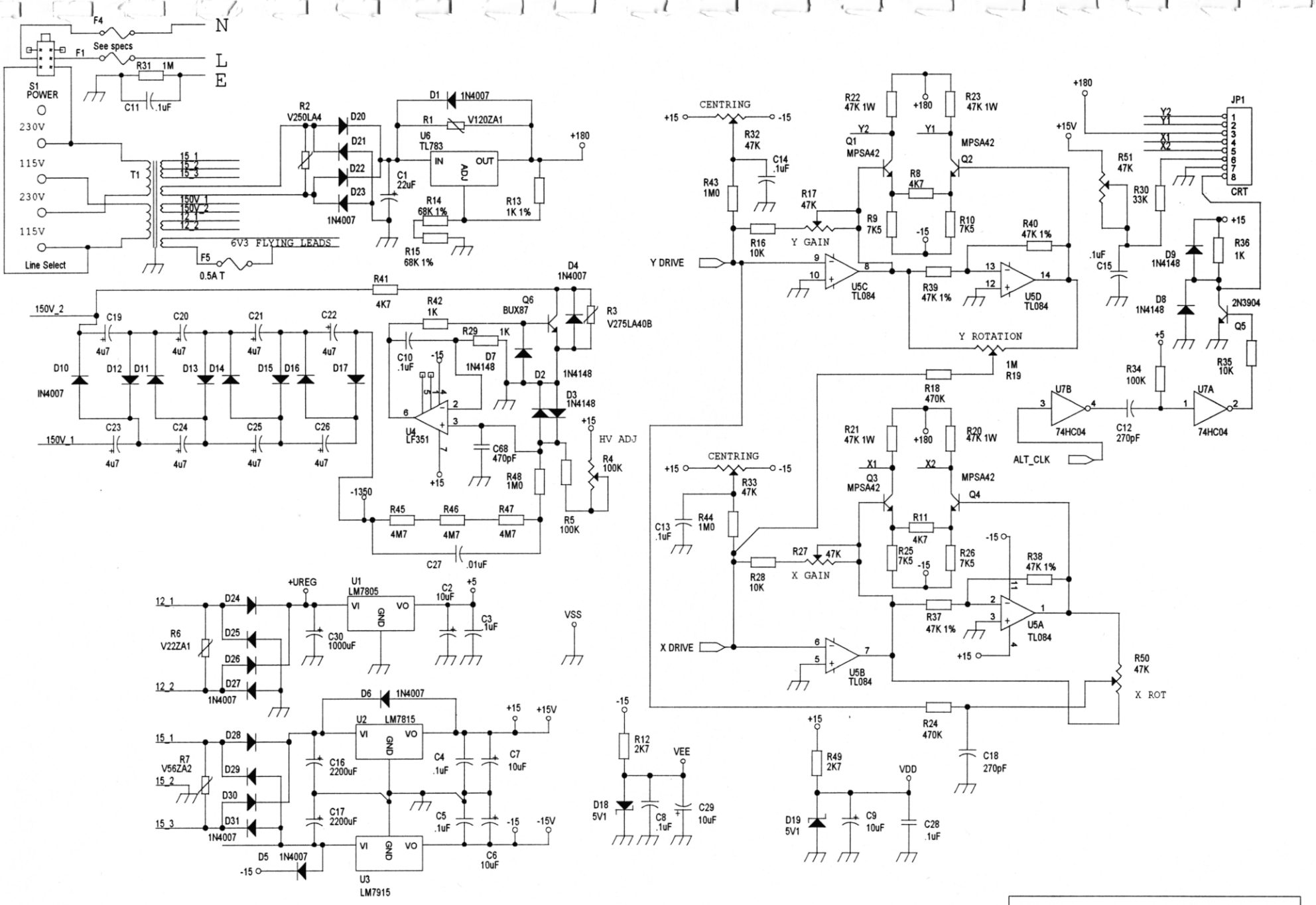
Early instruments were fitted with a different set of resistors in the high and medium range divider networks.

Cct. Ref.	Old Value	Old P/No.	New Value	New P/No.
R204, R205	12K 1%	RCT12K	10K 1%	RCT10K
R73, R74	20K 1%	RCT20K	19K1 1%	RCT19K1
R70, R71	8K06 1%	RCT8K06	8K66 1%	RCT8K66
R72, R77	43K 1%	RCT43K	44K2 1%	RCT44K2

The old and new circuit configurations are shown below:-



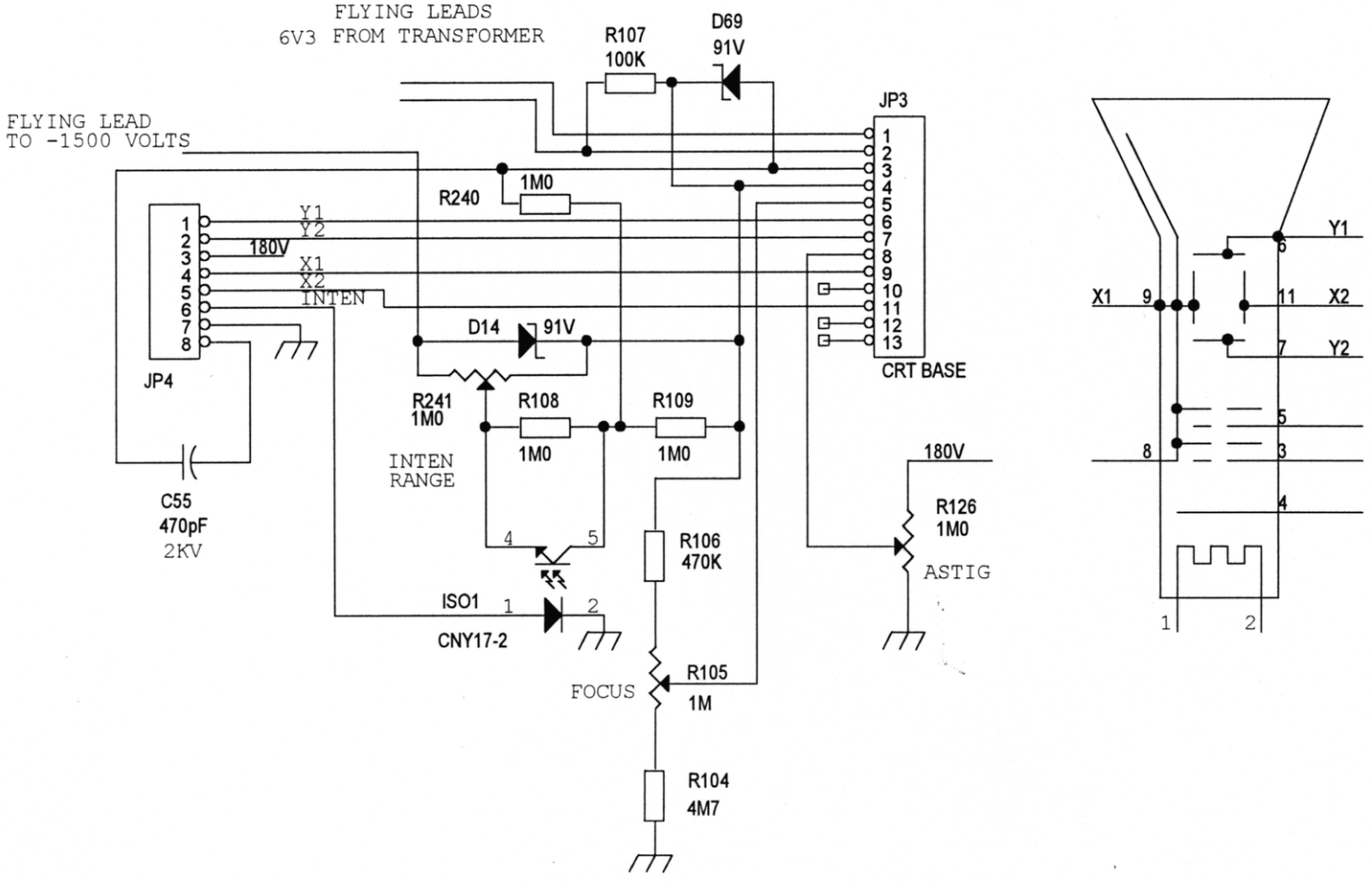




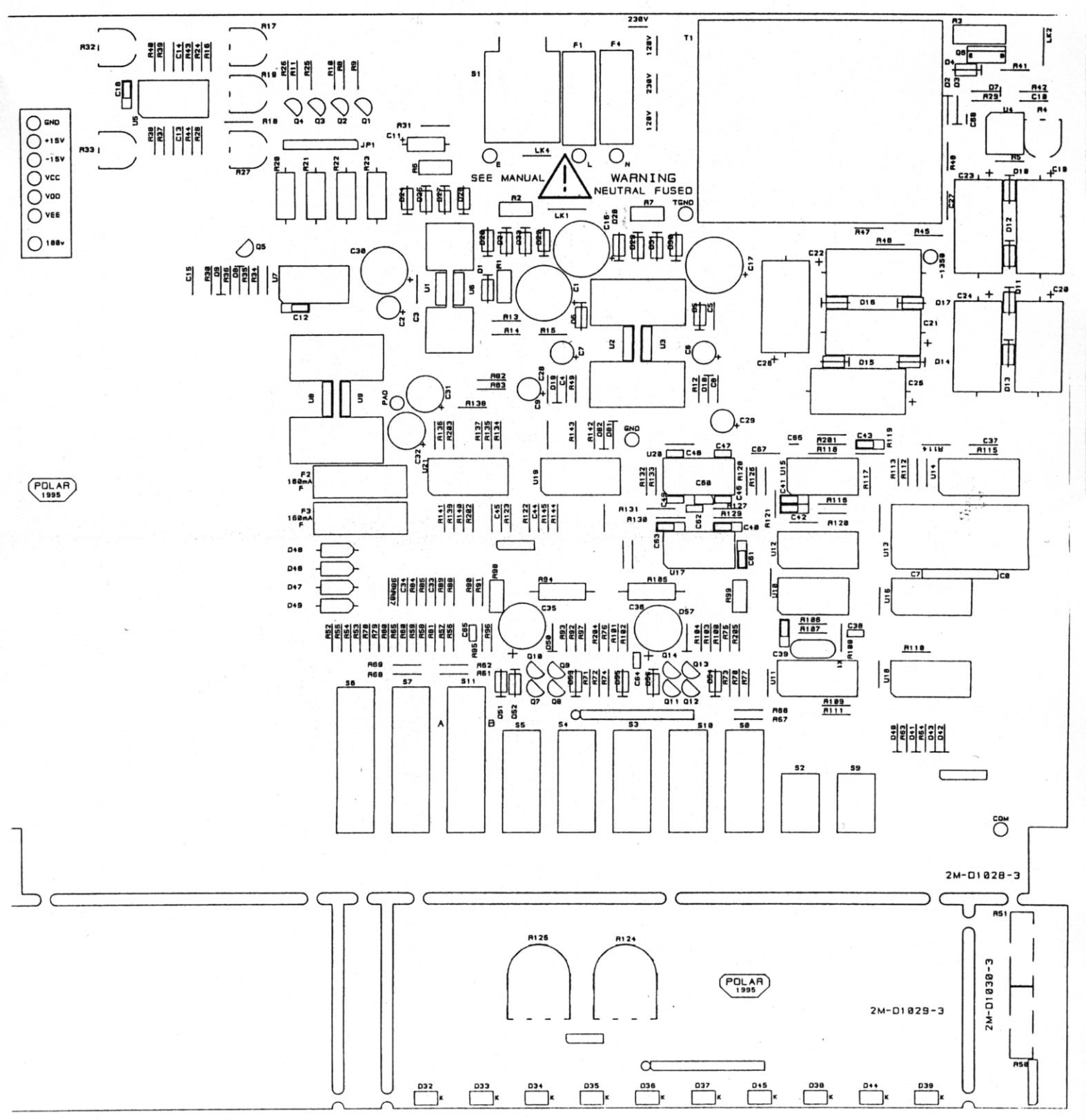
Polar

Polar Instruments Ltd
Garenne Park, St. Sampsons
Guernsey, Channel Islands

Inst.	Title
T1500A	Power Supplies



Polar	Polar Intruments Ltd Garenne Park, St. Sampsons Guernsey, Channel Islands
Inst. T1500A	Title CRT


GND
+15V
-15V
VCC
VDD
VEE
188v
POLAR
1995
SEE MANUAL
WARNING
NEUTRAL FUSED
2M-D1028-3
2M-D1029-3
2M-D1030-3
COM